

# Microwave Measurements of Middle Atmospheric Water Vapor From Mauna Loa, 1996-2001

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## INTRODUCTION

The Naval Research Laboratory Water Vapor Millimeter-wave Spectrometer (WVMS) system has been making nearly continuous middle-atmospheric water vapor profile measurements at Mauna Loa, Hawaii (19.5°N, 204.4°E), since March 1996. The measurements are made at 22 GHz, an emission line that is sufficiently optically thin to allow ground-based measurements of the middle atmosphere through the troposphere. The Mauna Loa site is ideal for these measurements both because of its high altitude, which minimizes the tropospheric signal, and because of its relatively low latitude, which minimizes the seasonal variations in the middle atmosphere and thus simplifies the monitoring of long-term changes in middle-atmospheric water vapor.

Measurements of water vapor provide important information on several processes in the middle atmosphere. Water vapor is an ideal transport tracer and has been used in numerous studies of atmospheric transport in the middle atmosphere [e.g., Bevilacqua *et al.*, 1990; Nedoluha *et al.*, 1996; Summers *et al.*, 1997]. Water vapor is also the reservoir of odd hydrogen in the middle atmosphere, and, although the studies of short-term variations in Halogen Occultation Experiment (HALOE) data (D.E. Siskind *et al.*, A search for an anticorrelation between H<sub>2</sub>O and O<sub>3</sub> in the lower mesosphere, submitted to *Journal of Geophysical Research*, 2002) suggest that the effect of water vapor on ozone is not yet well described by standard photochemical models, it is important to ozone chemistry. Changes in middle-atmospheric water vapor may also impact stratospheric temperatures and thus indirectly affect ozone depletion [Kirk-Davidoff *et al.*, 1999].

## WVMS MEASUREMENTS

The WVMS3 instrument at Mauna Loa is the third such instrument to be deployed. It is essentially identical to the WVMS2 instrument that operated at the Network for the Detection of Stratospheric Change (NDSC) site at Table Mountain, California (34.4°N, 242.3°E), from August 1993 to November 1997. These instruments are both very similar to the WVMS1 instrument that is taking measurements at the NDSC site at Lauder, New Zealand (45.0°S, 169.7°E).

The retrieval of a vertical water vapor profile with ground-based microwave measurements relies upon the change in pressure as a function of altitude. The line width of the spectrum decreases monotonically with altitude due to

the dependence on pressure broadening. Thus the resultant signal, which is the sum of the emission from all altitudes, can be deconvolved to retrieve a vertical profile. Details of the measurement technique and instrumentation are given by Nedoluha *et al.* [1995, 1996].

The mixing ratios retrieved from 40 to 80 km using 500 scan (~1 wk) integrations are shown in Figure 1. There is a summer peak in the upper mesospheric mixing ratio consistent with the upward motion of the atmosphere in the summer hemisphere. The large positive trend in water vapor that was observed by the WVMS instruments at Table Mountain and Lauder and by HALOE in the early 1990s [Nedoluha *et al.*, 1998] is not apparent in the data from Mauna Loa since 1996. Nevertheless, interesting variations are captured by both HALOE and the ground-based instruments.

A comparison of WVMS and HALOE data at several altitudes is shown in Figure 2. There is an offset between the average values of the HALOE and WVMS measurements at 50 km and 60 km, but the annual and interannual variations at Mauna Loa are very similar. Note in particular the interannual variation in the December/January minima at and above 60 km. Similar variations from WVMS measurements at Table Mountain and from

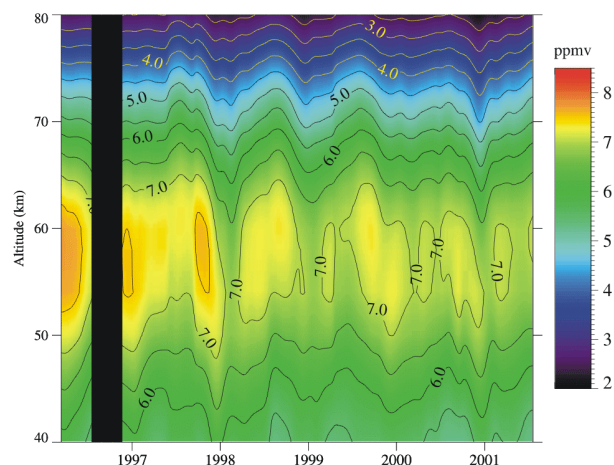


Fig. 1. Water vapor mixing ratios retrieved from WVMS3 measurements at Mauna Loa, Hawaii (19.5°N, 204.4°E). The data are smoothed using a Gaussian filter with a (1/e) width of 25 days.

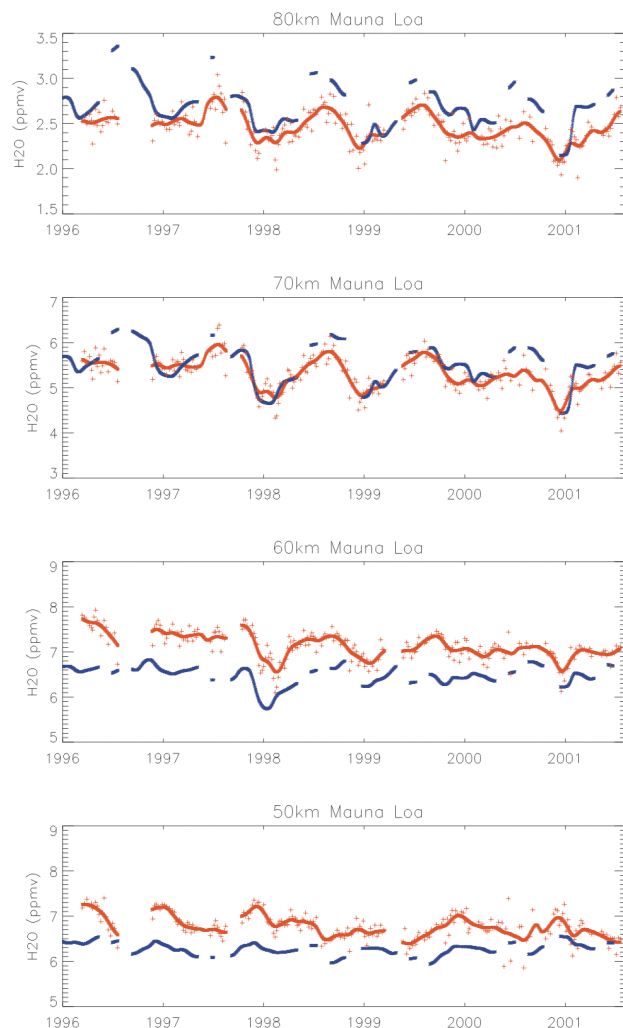


Fig. 2. Lines: WVMS (red) and HALOE (blue) data at several altitudes smoothed as in the contour plots. Measurement gaps of >50 days are left blank. Points: WVMS retrievals from approximately weekly averaged integrations. The HALOE data are all taken from within  $\pm 5^\circ$  latitude of the WVMS measurements, and have been convolved with the WVMS averaging kernels to present data with similar sensitivity and resolution.

earlier HALOE data suggest that these variations may be related to the quasi-biennial oscillation (QBO) [Nedoluha *et al.*, 2000]. Preliminary comparisons with interannual variations in High Resolution Doppler Imager (HRDI) zonal winds and with interannual variations in HALOE temperatures suggest that there may be a correlation between strong zonal wind gradients, high temperatures, and low water vapor mixing ratios in the upper mesosphere.

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